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Can Thermal Input from a Prior Universe Account for Relic Graviton Production and Imply Usage of the Bogomolnyi Inequality, as a Bridge between Brane World Models and Loop Quantum Gravity in Early Universe Conditions?

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Abstract

The author uses a low temperature and low entropy pre inflation state to create a bridge between String theory and loop quantum gravity. We use this analysis in lieu of the CMB barrier as of *z* = 1000 since it is our way to come up with a working model of quintessence scalar fields, which permits relic generation of dark matter and dark energy. Not only referencing this bridge, we do it in such a way as to utilize the low entropy condition which the Brane world model of Randal and Sundrum creates, and to show how it is in common with what Caroll and Chen wrote up in 2005., *i.e.* when the universe was about 1000 times smaller and 100,000 times younger than today.

Keywords

Branes, Axion Walls, Bogomolnyi Inequality, Four- and Five-Dimensional Cosmological Constant

1. Introduction

Our task is to first answer if there are "vacuum states" created out of "nothing", and this is done because vacuum

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fluctuations create dark energy density. The dark energy density is connected with an axion wall, which is dissolved by inflationary expansion. It is given by Weinberg [1] that the process of dissolving that wall occurs when relic background temperature is about 10^{32} Kelvin, *i.e.* the high temperature of 10^{32} Kelvin is the beginning of the onset of quantum gravity [1]. Interesting enough, the pre big bang state may be, as Penrose suggested in [2], low temperature and low energy. And this is paradoxical since while the pre big bang model has both low temperature and low entropy, the big bang model has high temperature and low entropy.

Still though, as written up by L. Crowell [3] in "Quantum Fluctuations in Space-Time", we can make a first principle argument as to the uncertainty principle in quantum mechanics being derivable from variations in the space time metric, and especially in the g_{00} component of the metric g_{ij}, *i.e.* $L \cdot \delta g \approx \delta g_{00} \cdot c^2$, where L is a unit length for evaluation of quantum fluctuations. From there we can then argue that fluctuations in dark energy density were initially of the form $\delta\rho_{DE} \approx \sqrt{\delta\rho_\Lambda} \cdot \sqrt{\rho_{\text{Planck length}}}$ with $\delta\rho_\Lambda$ connected with energy density fluctuations due to variations w.r.t. temperature in the Planck "constant" parameter in a formulation first presented by Park *et al*. [4]. We are assuming that this variation of the Planck "constant" parameter is also connected with relic graviton production. And we use a short time interval quintessence equation of "motion" in order to show a bridge between a pre inflationary quantum bounce thermal inputs of energy and initially cooled down states of matter conditions as postulated by Carroll and J. Chen [5], 2005 to Guth style quadratic potential inflation.

Also, relatively recently, quintessence models were for large time scales ruled out, and Padmanabhan [6] in a 2005 world press scientific tome edited by Abbay Ashtekar on pp. 175-204 notes that this is due to the cosmological constant being set to zero for the quintessence models being considered. This is due in part to the classes of potentials offered along the lines of Equation (18) of Padmanabhan's article [6], which we did not use, as well as the duration of the quintessence period being far larger than Planck's time interval. We got about this by using a different scalar model than what Padmanabhan used and also by using a vanishingly small time interval at the onset of the regime just before inflation to have quintessence scalar field evolution. We assume explicitly a collapse of axion walls leading to the chaotic inflationary potential first written up by Guth in the 1980s. As it is, our present paper is in response to suggestions by Dr. Wald [7] (2005), Sean Carroll and Jennifer Chen [5] (2005), with others in the University of Chicago physics department, about a Jeasun stability criteria leading to low entropy states of the universe at the onset of conditions before inflationary physics initiated expansion of inflaton fields. We agree with their conclusions and think it ties in nicely with the argument presented as to a burst of relic gravitons being produced. This is also consistent with an answer as to the supposition for the formation of a unique class of initial vacuum states, answering a question Guth [8] raised in 2003 about if or not a preferred form of vacuum state for early universe nucleation was obtainable. This is in tandem with the addition of gravity changing typical criteria for astrophysical applications of the jeans instability criteria [9] for weakly interacting fields, as mentioned by Penrose [2].

Contemporary graviton theory states that there is a thermal upsurge which initiates the growth of graviton physics. This is shown in K. E. Kunzes' well written (2002) article [10] which gives a lucid introduction as to early universe additional dimensions giving a decisive impetus to giving additional momentum to the production of relic gravitons. However, Kunze [10] is relying upon enhanced thermal excitation states, which contradict the Jeans instability criteria which appear to rule out a gravitational field soaked initial universe configuration being thermally excited. Is there a way to get around this situation which appears to violate the Jeans instability criteria for gravitational fields/gravitons in the early universe mandating low entropy states? We believe that there is, and that it relies upon a suggestion given by A. Ashtekar, T. Pawlowski and P. Singh (2006) [11] [12] as to the influence of the quantum bounce via quantum loop gravity mirror imaging a prior universe collapsing into a "singularity" with much the same geometry as the present universe. If this is the case, then we suggest that an energy flux from that prior universe collapse is transferred into a low entropy thermally cooled down initial state, leading to a sudden burst of relic gravitons as to our present universe configuration. The first order estimate for this graviton burst comes from the numerical density equation for gravitons written up by Weinberg as of 1972 [1] with an exponential factor containing a frequency value divided by a thermal value, T, minus 1. If the frequency value is initially quite high, and the input given by a prior universe "bounce", with an initial very high value of energy configuration, then we reason that this would be enough to introduce a massive energy excitation into a thermally cooled down axion wall configuration which would then lead to the extreme temperatures of approximately 10^{12} Kelvin forming at or before a Planck interval of time t_P, plus a meltdown of the axion domain wall, which we then says presages' formations of a Guth style inflationary quadratic and the onset of chaotic inflationary expansion.

A way of getting to all of this is to work with a variant of the Holographic principle and an upper bound to entropy calculations. R. Busso and L. Randall (2001) [13] give a brane world variant of the more standard upper bounds for entropy in terms of area calculations times powers of either the fourth or fifth dimensional values of Planck mass (45), which still lead to minimized values if we go near the origins of the big bang itself. Our observations are then not only consistent with the upper bound shrinking due to smaller and smaller volume/area values of regions of space containing entropy measured quantities, but consistent with entropy/area being less than or equal to a constant times absolute temperatures, if we assume at the beginning low temperature conditions prior to the pop up of an inflation scalar field.

Recently, Bo Feng *et al*. [14] introduced the idea of an effective Lagrangian to compliment the idea of CPT violations as new physics, with a term proportional to the derivative of a scalar field φ (in this case a quintessence field) times the dual of the electromagnetic tensor. What we are supplying is a proof if you are of time dependence of the quintessence scalar field, and Bo Feng *et al*. [14] inputs into the electric and magnetic fields of this dual of the E & M tensor from the stand point of CMB. It is noteworthy to bring up that Ichiki *et al*. [15] notes that because standard electromagnetic fields are coupled to gravity, magnetic fields simply dilute away as the universe expands, *i.e.* we need to consider the role of gravity generation in early universe models. We will, in this document try to address how, via graviton production, we have intense gravity wave generation, and also how to use this as a probe of early universe quintessence fields, and also how to get around the fact that conventional cosmological CMB is limited by a barrier as of a red shift limit of about $z \approx 1000$, *i.e.* when the universe was about 1000 times smaller and 100,000 times younger than today as to photons, *i.e.* we are confirming as was stated by Weinberg [1] as of 1972 that there is no chance of relic photon generation from the big bang itself and that we are using relic gravitons as a probe to the physics of quintessence fields. We are assuming that our probe may help us answer questions as to the origins of physics matters relevant to the dark matter/dark energy issue.

In addition this approach accounts for data suggesting that the four-dimensional version of the "cosmological constant" in fact varies with respect to external background temperature. If this temperature significantly varies during early universe baryogenesis, the end result is that there would be a huge release of spin-two gravitons in the early stages of cosmic nucleation of a new universe. It also answers whether "Even if there are 10^{1000} vacuum states produced by String theory, then does inflation produces overwhelmingly one preferred type of vacuum states over the other possible types of vacuum states?" [8] (Guth, 2003).

Also, we also account for the evolution of an equation of motion of a quintessence field, via equations given to us by M. Li, X. Wang, B. Feng, and X. Zhang [16], which is a first ever model as to the interaction of a quintessence scalar field with baryonic "normal matter" assuming varying contributions to a potential field system with a varying by temperature axion mass contribution to an evolving pre inflationary state, which collapses to a quadratic Guth style inflationary state with a suitable rise in initial inflationary temperatures.

Finally, we can state unequivocally that the typical dark energy SUGRA potential, *i.e.* for times $0 < t \approx t_P$ or larger

$$V(\phi) = \frac{\Lambda^{\alpha+4}}{\phi^{\alpha}} \cdot \exp\left(+4 \cdot \pi \cdot \phi^2 \big/ m_{\text{Planck}}^2\right) \tag{1}$$

blends/overlaps well with the finalized Guth style inflationary quadratic potential so derived in our formulation of this problem after we have a thermal input from a quantum bounce which melts axion walls. This is the case only because the intervals of time are so short as to merely indicate that Equation (1) merely indicates the growth behavior of a quantum vacuum state. In addition, we should also mention that the super nova survey, called Essence, has experimentally measured the "dark energy"—the thing that is causing the acceleration of the universe—to better than within 10% accuracy. The feature of this dark energy that was measured is its "equation of state". So far it looks that the strange acceleration of the expansion of the universe can be explained by Einstein's "cosmological constant". Note that in modern terms the cosmological constant is viewed as a quantum mechanical phenomenon called the "energy of the vacuum", in other words, the energy of empty space. And our work leads to the standard cosmological constant value well within the 1000 year limit of observational accuracy after the big bang, due to thermal cooling off which would occur about the $z = 1000$ or so red shift limit. This being the case, we will construct the following two tables for outlining the principles involved.

We look at the cosmological constant in 5 dimensions, and after it is given an absolute value give it as in Equation (2) below, we are finding that the absolute value is inversely proportional to temperature, T, as given below.

This is with regards to

$$\left|\Lambda_{5\text{-dim}}\right| \propto c_1 \cdot (1/T) \tag{2}$$

Note that the non absolute value version of the contents of Equation (2) is negative valued which is very important, as the negative sign given to Equation (2) contents is put in string theory, to exhibit a different character for the string theory's version of the cosmological constant than what is given in the four dimensional case.

In comparison, the four dimensional cosmological constant is positive valued we write as

$$\Lambda_{4\text{-dim}} \propto c_2 \cdot T \tag{3}$$

In comparison, if we have a temperature decrease of cosmological temperature to 10^{12} Kelvin, both Equation (2) and Equation (3) exhibit the following claimed linkage as given in Equation (4), noting that if $\Lambda_{5\text{-dim}} \approx -c_1 \cdot T^{-1}$ that then we have to an order 1/n that

$$\frac{\Lambda_{4-\text{dim}}}{\left|\Lambda_{5-\text{dim}}\right| \approx c_1 T^{-1}} \sim 1 - O(1/n) \tag{4}$$

It is useful to note a spatial relationship between the four and five dimensional cosmological constant parameters *i.e.* that the parameterization of the absolute value of the four and five dimensional constant have the following behavior.. *I.e.* the length scale between the two representations is similar

$$L \propto L\left(\Lambda_{4\text{-dim}}\right) \propto O\left(\left|\Lambda_{5\text{-dim}}\right|\right) \tag{5}$$

So being the case, we get a simple case of where we can analyze vacuum energy density fluctuations in the region of space smaller than the radii given in Equation (5) above, via

$$\Delta\rho_{\text{vacuum}} \propto l_P^{-2} \cdot L^{-2}\left(\Lambda_{4\text{-dim}} \approx \left|\Lambda_{5\text{-dim}}\right|\right) \propto H^2\left(\Lambda_{4\text{-dim}} \approx \left|\Lambda_{5\text{-dim}}\right|\right) / G \tag{6}$$

This is with respect to working with dimensions of the order of Plancks length, *i.e.* the volume of space where the volume of space has a radii which is of the order of, for $0 \le \tilde{\alpha} \le N_+$

$$L\left(\Lambda_{4\text{-dim}} \approx \left|\Lambda_{5\text{-dim}}\right|\right) \approx 10^{\tilde{\alpha}} \times \left(l_P = 0.1616 \times 10^{-33}\ \text{cm}\right) \tag{7}$$

where initially we have temperatures of the order of 1.4 times 10 to the 32 power Kelvin as a thresh hold for the existence of quantum effects. This would pre suppose answering the issue raised by Weinberg [1]. As of 1972, he wrote that for quantum effects to be dominant in cosmology, with a value of critical energy we will use in setting a template for relic graviton production later on.

$$E_{\text{critical}} \equiv 1.22 \times 10^{28}\ \text{eV} \tag{8}$$

This is pre supposing that we have a working cosmology which actually gets to such temperatures at the instance of quantum nucleation of a new universe. And if there is no temperature dependence, in the 5th dimensional cosmological constant set as having magnitude Λ, we still can get a five dimensional line element [17] as given by

$$\mathrm{d}S_{5\text{-dim}}^2 \cong \frac{\Lambda \cdot l^2}{3} \cdot \left\{\text{4-dim Schwartzshield deSitter metric}\right\} - \mathrm{d}l^2 \tag{9}$$

2. Fluctuations and Their Linkage to Brane World Physics

We shall reference a simple Lypunov Exponet argument as to adjustment of the initial quantum flux on the brane world picture. This will next be followed up by a description of how to link the estimated requirement of heat influx needed to get the quantum spatial variation flux in line with inflation expansion parameters.

To begin this, we access the article "Quantum theory without Measurements" to ascertain the role of a Lyapunov exponent $\tilde{\Lambda}_{chaos}$ [18] such that

$$\Delta p = \left(\Delta p_0\right) \cdot \exp\left(-\tilde{\Lambda}_{chaos} \cdot t\right) \tag{10}$$

and

$$\Delta x = \left(\hbar / \Delta p_0\right) \cdot \exp\left(\tilde{\Lambda}_{chaos} \cdot t\right) \tag{11}$$

Here, we define where a wave functional forms via the minimum time requirement as to the formation of a wave functional via a minimum time of the order of Planck's time

$$t_h = \left(\tilde{\Lambda}_{chaos}\right)^{-1} \cdot \ln\left[\Delta p_0 \cdot \widehat{L}/\hbar\right] \approx t_P \tag{12}$$

If we have a specified minimum length as to how to define $\widehat{L} \approx l_P$, this is a good way to get an extremely large $\tilde{\Lambda}_{chaos}$ value, all in all so that we have Equation (3) above on the order of magnitude at the end of inflation as large as what the universe becomes, *i.e.* a few centimeters or so, from an initial length value on the order of Planck's length $\widehat{L} \approx l_P$.

3. Why Bother with Talking about Such a Simplified Fluctuation Procedure?

Two reasons First of all, we have that our description of a link of the sort between a brane world effective potential and Guth style inflation has been partly replicated by Sago, Himenoto, and Sasaki in November 2001 [19] where they assumed a given scalar potential, assuming that *m* is the mass of the bulk scalar field

$$V(\phi) = V_0 + \frac{1}{2} m\phi^2 \tag{13}$$

Their model is in part governed by a restriction of their 5-dimensional metric to be of the form, with *l* = brane world curvature radius, and *H* their version [19] of the Hubble parameter

$$\mathrm{d}S^2 = \mathrm{d}r^2 + (H \cdot l)^2 \cdot \mathrm{d}S^2_{4\text{-dim}} \tag{14}$$

i.e. if we take k_5^2 as being a 5 dimensional gravitational constant

$$H = \frac{k_5^2 \cdot V_0}{6} \tag{15}$$

Our difference with Equation (102) of Sago *et al.* [19] is that we are proposing that it is an intermediate step, and not a global picture of the inflation field potential system. However, the paper they present with its focus upon the zero mode contributions to vacuum expectations $\langle \delta\phi^2 \rangle$ on a brane has similarities as to what we did which should be investigated further. The difference between what they did, and our approach is in their value of [19]

$$\mathrm{d}S^2{}_{4\text{-dim}} \equiv -\mathrm{d}t^2 + \frac{1}{H^2} \cdot \left[\exp(2 \cdot H \cdot t)\right] \cdot \mathrm{d}x^2 \tag{16}$$

which assumes one is still working with a modified Gaussian potential all the way through. This is assuming that there exists an effective five dimensional cosmological parameter which is still less than zero, with $\Lambda_5 < 0$, and $|\Lambda_5| > k_5^2 \cdot V_0$ so that

$$\Lambda_{5,eff} = \Lambda_5 + k_5^2 \cdot V_0 < 0 \tag{17}$$

It is simply a matter of having

$$|m^2| \cdot \phi^2 \ll V_0 \tag{18}$$

And of making the following identification

$$\phi_{5\text{-dim}} \propto \tilde{\phi}_{4\text{-dim}} \equiv \tilde{\phi} \approx \left[\phi - \varphi_{\text{fluctuations}}\right]_{4\text{-dim}} \tag{19}$$

$\varphi_{\text{fluctuations}}$ in Equation (19) is an equilibrium value of a true vacuum minimum for a chaotic four dimensional quadratic scalar potential for inflationary cosmology. This in the context of the fluctuations having an upper bound of $\tilde{\tilde{\phi}}$ PP (Here, $\tilde{\tilde{\phi}} \geq \varphi_{\text{fluctuations}}$). And $\tilde{\phi}_{4\text{-dim}} \equiv \tilde{\tilde{\phi}} - \frac{m}{\sqrt{12 \cdot \pi \cdot G}} \cdot t$, where we use $\tilde{\tilde{\phi}} > \sqrt{\frac{60}{2 \cdot \pi}} M_P \approx 3.1 M_P \equiv 3.1$, with M_P being a Planck mass. This identifies an imbedding structure we will elaborate upon later on. His will in its own way lead us to make sense of a phase transition we will write as a four dimensional embedded structure within the 5 dimensional Sundrum brane world structure and the four dimensional

$$\begin{array}{ll} \tilde{V}_1 & \to \tilde{V}_2 \\ \tilde{\phi}(\text{increase}) \le 2\cdot\pi & \to \tilde{\phi}(\text{decrease}) \le 2\cdot\pi \\ t \le t_P & \to t \ge t_P + \delta\cdot t \end{array} \tag{20}$$

The potentials $\tilde{V}_1$, and $\tilde{V}_2$ will be described in terms of **S-S'** di quark pairs nucleating and then contributing to a chaotic inflationary scalar potential system. Here, $m^2 \approx (1/100)\cdot M_P^2$

$$\tilde{V}_1(\phi) \propto \frac{m_a^2(T)}{2}\cdot\left(1-\cos\left(\tilde{\phi}\right)\right)+\frac{m^2}{2}\cdot\left(\tilde{\phi}-\phi^*\right)^2 \tag{21}$$

$$\tilde{V}_2(\phi) \propto \frac{1}{2}\cdot\left(\tilde{\phi}-\phi_C\right)^2 \tag{22}$$

This is where for low temperatures $m_a^2\left(T\approx\varepsilon^+\right)\cong 100\cdot m^2 \xrightarrow[T\to\text{large}]{} m_a^2\left(T\approx 10^{12}\ \text{K}\right)\ll m^2$ *i.e.* we look at axion walls specified by Kolb's book [20] about conditions in the early universe (1991) with his Equation (10) and Equation (27) vanishing and collapsing to Guth's quadratic inflation. *i.e.* having the quadratic contribution to an inflation potential arise due to the vanishing of the axion contribution of the first potential of Equation (21) above with a temperature dependence of [20]

$$V(a) = m_a^2\cdot\left(f_{PQ}/N\right)^2\cdot\left(1-\cos\left[a/\left(f_{PQ}/N\right)\right]\right) \tag{23}$$

Here, he has the mass of the axion potential as given by m_a as well as a discussion of symmetry breaking which occurs with a temperature $T \approx f_{PQ}$. This is done via scaling the axion mass via either [21]

$$m_a(T) \approx 3\cdot H(T) \tag{24}$$

So that the axion "matter" will oscillate with a "frequency" proportional to $m_a(T)$. The hypothesis so presented is that input thermal energy given by the prior universe being inputted into an initial cavity/region dominated by an initially configured low temperature axion domain wall would be thermally excited to reach the regime of temperature excitation permitting an order of magnitude drop of axion density ρ_a from an initial temperature[2] $T_{dS}\big|_{t\le t_P} \sim H_0 \approx 10^{-33}$ eV as given by (assuming we will use the following symbol ψ_a for axions, and then relate it to Guth inflationary potential scalar fields [8] later on, and state that $\psi_a(t)=\psi_i$ is the initial misaligned value of the field)

$$\rho_a(T_{ds}) \propto \frac{1}{2}\cdot m_a(T_{dS})\cdot\psi_i^2 \xrightarrow[T\to 10\text{ to 12th power Kelvin}]{} \varepsilon^+ \tag{25}$$

Or

$$m_a(T) \cong 0.1\cdot m_a(T=0)\cdot\left(\Lambda_{QCD}/T\right)^{3.7} \tag{26}$$

This axion treatment is similar, in a lower dimensional sense to the work which is presented in [22] [23] physics while the work done by [22] [23] is an elaboration for much of the physics which is done in Equation (24) to Equation (26).

The dissolving of axion walls is necessary for dark matter-dark energy production and we need to incorporate this in a potential system in four dimensions, and relate it to a bigger five dimensional potential systems. We need to find a way to, using brane theory, to investigate how we can have non zero axion mass conditions to begin with. This will be done after we bring up a brief interlude of Quintessence evolution of the scalar field, which for long periods of time is unworkable, but which would be appropriate up to times in the order of magnitude of the Planck's time coefficient. Note after this description of Quintessence, we will be looking at the mechanism of thermal input leading to the time dependence of the axion mass, as given in Equation (26) above.

4. Dynamics of Axion Interaction with Baryonic Matter, via Quintessence Scalar Field

This discussion is modeled on an paper on Quintessence and spontaneous Leptogenesis (baryogenesis) by M. Li, X. Wang, B. Feng, and Z. Zhang [16] which gave an effective Lagrangian, and an equation of "motion" for quintessence which yielded four significant cases for our perusal. The last case, giving a way to reconcile the influx of thermal energy of a quantum bounce into an axion dominated initial cosmology, which lead to dissolution of the excess axion "mass". This final reduction of axion "mass" via temperature variation leads to the Guth style chaotic inflationary regime [8].

Let us now look at a different effective Lagrangian which has some similarities to equations of motion for Quintessence scalar fields, assuming that specifying a non zero value to $(\partial_0 \phi)$ where $(\partial_0 \phi) \neq 0$ is implicitly assumed in Equation (20) to Equation (22) *i.e.* [16]

$$L_{eff} \propto \frac{\tilde{c}}{M} \cdot (\partial_\mu \phi) \cdot J^\mu \tag{27}$$

What will be significant will be the constant, $\tilde{c}$ which is the strength of interaction between a quintessence scalar field and baryonic matter. M in the denominator is a mass scale which can be either $M \equiv M_{\text{planck}}$, or $M \equiv M_{\text{GUT}}$ is not so important to our discussion, and J^μ is in reference to a baryonic "current". The main contribution to our analysis this paper gives us is in their quintessence "equation of motion" which we will present, next. Note, that what we are calling g_b is the degrees of freedom of baryonic states of matter, and T is a back ground temperature w.r.t. early universe conditions. $H \cong 1/t(\text{time})$ is the Hubble parameter, with time $t \propto O(t_P)$, *i.e.* time on the order of Planck's time, or in some cases much smaller than that.

$$\ddot{\phi} \cdot \left[1 + \frac{\tilde{c}}{M^2} \cdot \frac{T^2}{6} \cdot g_b\right] + 3 \cdot H \cdot \dot{\phi} \cdot \left[1 + \frac{\tilde{c}}{M^2} \cdot \frac{T^2}{6} \cdot g_b\right] + \left(\frac{\partial V_{\text{axion-contri}}}{\partial \varphi}\right) \cong 0 \tag{28}$$

Here I am making the following assumption about the axion contribution scalar potential system

$$V_{\text{axion-contri}} \equiv f\left[m_{\text{axion}}(T)\right] \cdot \left(1 - \cos(\phi)\right) + \frac{m^2}{2} \cdot (\phi - \phi_C)^2 \tag{29}$$

For low temperatures, we can assume that prior to inflation, as given by Carroll and Chen [5] we have for $t \ll t_P$

$$f\left[m_{\text{axion}}(T)\right]_{T \approx 2\ \text{Kelvin}} \propto O\left((50 - 100) \cdot m^2\right) \tag{30}$$

And that right at the point where we have a thermal input with back ground temperatures at or greater than 10^{12} Kelvin we are observing for $0 < \varepsilon^+ \ll 1$ and times $t \ll t_P$

$$f\left[m_{\text{axion}}(T)\right]_{T \approx 10^{12}\ \text{Kelvin}} \propto O\left((\varepsilon^+) \cdot m^2\right) \tag{31}$$

This entails having at high enough temperatures

$$V_{\text{axion-contri}}\Big|_{T > 10^{12}\ \text{Kelvin}} \cong \frac{m^2}{2} \cdot (\phi - \phi_C)^2 \tag{32}$$

Let us now review the four cases so mentioned and to use them to analyze new physics.

CASE I:

Look now at a low temperate slow roll case, which is also true when we get to time $\gg t_P$, doing this leads to

$$\begin{aligned} &\ddot{\phi} \cdot \left[1 + \frac{\tilde{c}}{M^2} \cdot \frac{T^2}{6} \cdot g_b\right] + 3 \cdot H \cdot \dot{\phi} \cdot \left[1 + \frac{\tilde{c}}{M^2} \cdot \frac{T^2}{6} \cdot g_b\right] + \left(\frac{\partial V_{\text{axion-contri}}}{\partial \phi}\right) \\ &\xrightarrow[T \to 0^+]{} 3 \cdot H \cdot \dot{\phi} \cdot + \left(\frac{\partial V_{\text{axion-contri}}}{\partial \phi}\right) \cong 0 \end{aligned} \tag{33}$$

CASE II:

If temperature is T very large and time of the order of Planck time. We ignore slow roll, and we use $H \propto 1/t_P$.

$$\ddot{\phi}\cdot\left[1+\frac{\tilde{c}}{M^2}\cdot\frac{T^2}{6}\cdot g_b\right]+3\cdot H\cdot\dot{\phi}\cdot\left[1+\frac{\tilde{c}}{M^2}\cdot\frac{T^2}{6}\cdot g_b\right]+\left(\frac{\partial V_{\text{axion-contri}}}{\partial\phi}\right)$$
$$\xrightarrow[T\to 10^{12}\text{ Kelvin}]{}\ddot{\phi}+3\cdot H\cdot\dot{\phi}\cdot+\left(\frac{\tilde{c}}{M^2}\cdot\frac{T^2}{6}\cdot g_b\right)^{-1}\cdot\left(\frac{\partial V_{\text{axion-contri}}}{\partial\phi}=m^2\cdot(\phi-\phi_C)\right)\cong 0 \tag{34}$$

We then use the following approximations $\phi_{\text{general}}\propto\exp(p\cdot t),\phi_{\text{particular}}\equiv\phi_C,\phi_{\text{Total}}=\phi_{\text{general}}+\phi_{\text{particular}}$, if so then,

$$p^2+3\cdot H\cdot p\cdot+\left(\frac{\tilde{c}}{M^2}\cdot\frac{T^2}{6}\cdot g_b\right)^{-1}\cdot(m^2)\cong 0$$
$$\to p\cong\left[-\frac{3H}{2}\cdot\left[2-4\cdot\frac{m^2\cdot M^2}{T^2\cdot c\cdot g_b H}\right],-\left(6\cdot\frac{m^2\cdot M^2}{T^2\cdot c\cdot g_b}\right)\approx-\varepsilon^+\right]\equiv[p_1,p_2] \tag{35}$$
$$\Rightarrow\phi_{\text{general}}\cong c_1\cdot\exp\left(-|p_1|\cdot t\right)+c_2\cdot\exp\left(-\left(|p_2|\approx\varepsilon^+\right)\cdot t\right)$$

$$\phi_{\text{Total}}=\phi_{\text{general}}+\phi_{\text{particular}}\cong\phi_C+\varepsilon_1\cdot\phi_{\text{initial value}}+H.O.T.,\ \text{ where }\ \varepsilon_1<1 \tag{36}$$

CASE III:

T very large and time almost Planck time t_P. This has $H\propto 1/t_P$. Note ,that the constant c IS specified to be a small quantity, *i.e.* we are not using Slow Roll here. So then

$$\phi_{\text{Total}}=\phi_{\text{general}}+\phi_{\text{particular}}\cong\phi_C+\varepsilon_1\cdot\phi_{\text{initial value}},\ \text{ where }\ \varepsilon_1<1 \tag{37}$$

Case IV:

T not large, so the Axion mass is not negligible, and time is almost t_P. NOT the slow roll case, and the Planck value $H>H_{t=t_P}\propto 1/t_P$. Begin with approximation of the Axion effective potential via

$$V_{\text{axion-contri}}\equiv f\left[m_{\text{axion}}(T)\right]\cdot(1-\cos(\phi))+\frac{m^2}{2}\cdot(\phi-\phi_C)^2$$
$$\Rightarrow\left(\frac{\partial V_{\text{axion-contri}}}{\partial\phi}\right)\xrightarrow[\text{Temperature getting larger}]{} \tag{38}$$
$$f\left[m_{\text{axion}}(T)\right]\cdot\frac{\phi^5}{125}-f\left[m_{\text{axion}}(T)\right]\cdot\frac{\phi^3}{6}+\left[\left(m^2+f\left[m_{\text{axion}}(T)\right]\right)\cdot\phi-m^2\phi\right]$$

Then we obtain

$$\ddot{\phi}+3\cdot H\cdot\dot{\phi}\cdot+\left(\frac{\tilde{c}}{M^2}\cdot\frac{T^2}{6}\cdot g_b\right)^{-1}\cdot\left(\frac{\partial V_{\text{axion-contri}}}{\partial\phi}\right)\cong 0 \tag{39}$$

This will lead to as the temperature rises we get that the general solution obeys

$$p^2+3\cdot H\cdot p\cdot+\left(\frac{\tilde{c}}{M^2}\cdot\frac{T^2}{6}\cdot g_b\right)^{-1}\cdot(m^2)\cong 0$$
$$\to p\cong\left[-\frac{3H}{2}\cdot\left[1\pm\sqrt{1-\frac{6\cdot M^2}{3\cdot T^2\cdot c\cdot g_b H}\cdot\left(m^2+f\left[m_{\text{axion}}(T)\right]\right)}\right]\right]\equiv[p_1,p_2]$$
$$\Rightarrow\phi_{\text{general}}\cong c_1\cdot\exp(p_1\cdot t)+c_2\cdot\exp(p_2\cdot t) \tag{40}$$
$$\propto\left[\phi(\text{real})+i\cdot\phi(\text{imaginary})\right]\ \text{ iff }\left[m_{\text{axion}}(T)\right]\text{ large}$$
$$\propto\left[\phi(\text{real})\right]\ \text{ iff }\left[m_{\text{axion}}(T)\right]\text{ small}$$

The upshot is, that we have a real field if the axion mass disappears. First of all, though, we have to understand how the conditions presented by S. Carroll, and J. Chen came about via brane theory.

5. Setting up Conditions for Low Temperature and Low Entropy Bounds via Brane World Physics for the Start of Inflation

Our starting point here is first showing equivalence of entropy formulations in both the Brane world and the more typical four dimensional systems. A Randall-Sundrum Brane world will have the following as a line element and we will continue from here to discuss how it relates to holographic upper bounds to both anti De sitter metric entropy expressions and the physics of dark energy generating systems.

To begin with, let us first start with the following as a $A \cdot \mathrm{d}S_5$ model of tension on brane systems, and the line elements. If there exists a tension $\breve{T}$, with Plank mass in five dimensions denoted as M_5, and a curvature value of l on $A \cdot \mathrm{d}S_5$ we can write [24]

$$\breve{T} = 3 \cdot \left(M_5^3 / 4 \cdot \pi \cdot l \right) \tag{41}$$

Furthermore, the $A \cdot \mathrm{d}S_5$ line element, with $r =$ distance from the brane, becomes similar to what was [25]

$$\frac{\mathrm{d}S^2}{l^2} = \left(\exp\left(2 \cdot r\right)\right) \cdot \left[-\mathrm{d}t^2 + \mathrm{d}\rho^2 + \sin^2 \rho \cdot \mathrm{d}\Omega_2 \right] + \mathrm{d}r^2 \tag{42}$$

We can then speak of a four dimensional volume V_4 and its relationship with a three dimensional volume V_3 via

$$V_4 = l \cdot V_3 \tag{43}$$

And if a Brane world gravitational constant expression $G_N = M_4^{-2} \Leftrightarrow M_4^2 = M_5^3 \cdot l$ we can get a the following space bound Holographic upper bound to entropy [24]

$$S_5\left(V_4\right) \le V_3 \cdot \left(M_5^3 / 4 \right) \tag{44}$$

If we look at an area "boundary" A_2 for a three dimensional volume V_3, we can re cast the above holographic principle to (for a volume V_3 in Planck units)

$$S_4\left(V_3\right) \le A_2 \cdot \left(M_4^2 / 4 \right) \tag{45}$$

We link this to the principle of the Jeans inequality for gravitational physics and a bound to entropy and early universe conditions, as given by S. Carroll and J. Chen (2005) [5] by stating if $S_4\left(V\right) = S_5\left(V_4\right)$ then if we can have

$$A_2 \xrightarrow[t \to t_P]{} \varepsilon_{\text{small area}} \Leftrightarrow S_5\left(V_4\right) \approx \delta_{\text{small entropy}} \tag{46}$$

Low entropy conditions for initial conditions, as stated above give a clue as to the likely hood of low temperatures as a starting point via R. Easther *et al*. (1998) [22] relationship of a generalized non brane world entropy bound, assuming that $n^* \approx$ bosonic degrees of freedom and T as generalized temperature, so we have as a temperature based elaboration of the original work by Susskind on holographic projections forming area bound values to entry

$$\frac{S}{A} \le \sqrt{n^*} \cdot T \tag{47}$$

Similar reasoning, albeit from the stand point of the Jeans inequality and instability criteria lead to Sean Carroll and J. Chen [5] (2005) giving for times at or earlier than the Planck time t_P that a vacuum state would initially start off with a very low temperature

$$T_{dS}\Big|_{t \le t_P} \sim H_0 \approx 10^{-33}\ \text{eV} \tag{48}$$

We shall next refer to how this relates to, considering a low entropy system as a start an expression Wheeler wrote for graviton production and its implications for early relic graviton production, and its connection to axion walls and how they subsequently vanish at or slightly past the Planck time t_P. This involves using relic graviton production as referenced next as a way to mark the influx of thermal heat. We after talking about thermal input will integrate the following equation to obtain a phenomenological way to mark how gravitons may arise naturally. Afterwards, we will.

6. The Wheeler Graviton Production Formula for Relic Gravitons

We use below the Wheeler black body approximation used in [1] for the production of gravitons, *i.e.* we obtain

$$n(\omega)\mathrm{d}\omega = \frac{\omega^2 \mathrm{d}\omega}{\pi^2} \cdot \left[\exp\left(\frac{2\cdot\pi\cdot\hbar\cdot\omega}{\bar{k}T}\right) - 1\right]^{-1} \tag{49}$$

Equation (49) is useful for, in a black body cavity setting for generating a burst of gravitons in a given frequency range. Now, here Equation (49) predicts a surge in gravitons being produced if there is a sharp increase in temperature. If the Early universe prior to the big bang were low temperature in character, with a subsequent build up to Planck temperature, then Equation (49) models an extreme graviton burst.

Here is how we can build up a scenario for just that. Equation (49) suggests that at low temperatures we have large busts of gravitons.

Now, how do we get a way to get the ω and $\omega + \mathrm{d}\omega$ frequency range for gravitons, especially if they are relic gravitons? First of all, we need to consider that certain researchers claim that gravitons are not necessarily massless, and in fact the Friedman equation acquires an extra dark-energy component leading to accelerated expansion. The mass of the graviton allegedly can be as large as ~ $(10^{15}\ \text{cm})^{-1}$. This is though if we connect massive gravitons with dark matter candidates, and not necessarily with relic gravitons. Having said this we can note that Massimo Giovannini [26] writes in about presenting a model which leads to post-inflationary phases whose effective equation of state is stiffer than radiation. He states: *The expected gravitational wave logarithmic energy spectra are tilted towards high frequencies and characterized by two parameters*: *the inflationary curvature scale at which the transition to the stiff phase occurs and the number of* (*nonconformally coupled*) *scalar degrees of freedom whose decay into fermions triggers the onset of a gravitational reheating of the Universe. Depending upon the parameters of the model and upon the different inflationary dynamics* (*prior to the onset of the stiff evolution*), *the relic gravitons energy density can be much more sizable than in standard inflationary models*, *for frequencies larger than* 1 *Hz.* Giovannini [26] claims that there are grounds for an energy density of relic gravitons in critical units (*i.e.*, $h_0^2\Omega_{GW}$) is of the order of 10^{-6}, roughly eight orders of magnitude larger than in ordinary inflationary models. That roughly corresponds with what could be expected in our brane world model for relic graviton production.

We also are as stated earlier, stating that the energy input into the frequency range so delineated comes from a prior universe collapse, as modeled by Ashtekar, A., Pawlowski, T. and Singh, P (2006) [11] [12] via their quantum bounce model as given by quantum loop gravity calculations. We will state more about this later in this document.

The subsequent analysis is for a low temperature axion wall domain wall in early universe structure. This will change, with the axion domain wall being 'melted' with a surge to Planck Temperature. We will next then talk more explicitly about Graviton production, aside from using the Wheeler Black Body model, given in Equation (49) above.

7. Graviton Space Propulsion Systems

We need to understand what is required for realistic space propulsion. To do this, we need to refer to a power spectrum value which can be associated with the emission of a graviton. Fortunately, the literature contains a working expression as to power generation for a graviton being produced for a rod spinning at a frequency per second ω, which is by Fontana (2005) [27] at a STAIF new frontiers meeting, which allegedly gives for a rod of length $\widehat{L}$ and of mass m a formula for graviton production power, [27], The first expression is a power of graviton based upon a rotating rod approximation, with the graviton given has having a mass of 10^{-60} - 10^{-62} grans, If so, then from Fontana [27] we have

$$P(\text{power}) = 2 \cdot \frac{m_{\text{graviton}}^2 \cdot \widehat{L}^4 \cdot \omega_{net}^6}{45 \cdot \left(c^5 \cdot G\right)} \tag{50}$$

First of all, we will integrate Equation (50), and also give a Planck length value to the rotating rod, and then we get Equation (51). One can see the results of integrating Equation (50), Note this expression for numerical production of gravitons is extremely sensitive to temperature, T, and se obtain

Table 1. How to outline the existence of a relic graviton burst.

N1 = 1.794E − 6 for $Temp = T^*$	Power = 0
N2 = 1.133E − 4 for $Temp = 2T^*$	Power = 0
N3 = 7.872E + 21 for $Temp = 3T^*$	Power = 1.058E + 16
N4 = 3.612E + 16 for $Temp = 4T^*$	Power ≅ very small value
N5 = 4.205E − 3 for $Temp = 5T^*$	Power = 0

$$\langle n(\omega)\rangle = \frac{1}{\omega(\text{net value})}\int_{\omega 1}^{\omega 2}\frac{\omega^2 \mathrm{d}\omega}{\pi^2}\cdot\left[\exp\left(\frac{2\cdot\pi\cdot\hbar\cdot\omega}{\bar{k}T}\right)-1\right]^{-1} \tag{51}$$

Then, if $E_{eff} \equiv \langle n(\omega)\rangle\cdot\omega \equiv \omega_{eff}$; with $\hbar\omega \xrightarrow[\hbar\equiv 1]{} \omega \equiv |E_{\text{critical}}|$ being given in Equation (51) above, we get a graviton burst as represented in **Table 1**, below, *i.e.* this was done assuming with T^* being an initial thermal background temperature of the pre inflationary universe condition of about 1/30 that of Planck temperature.

Assuming when one does this that the back ground in the initial inflation state causes a thermal heat up of the axion wall "material" due to a thermal input from a prior universe quantum bounce. Our next task will be to configure the conditions via brane world dynamics leading to graviton production. This necessitates using a brane world potential to accommodate the building of a structure accommodating a transition from relic graviton production to the onset of Guth style chaotic inflation.

8. Randall Sundrum Effective Potential

The consequences of the fifth-dimension show up in a simple warped compactification involving two branes, *i.e.*, a Planck world brane, and an IR brane. Let's call the brane where gravity is localized the Planck brane This construction permits (assuming K is a constant picked to fit brane world requirements) [27]-[29]

$$S_5 = \int \mathrm{d}^4x \cdot \int_{-\pi}^{\pi}\mathrm{d}\theta\cdot R\cdot\left\{\frac{1}{2}\cdot(\partial_M\phi)^2 - \frac{m_5^2}{2}\cdot\phi^2 - K\cdot\phi\cdot\left[\delta(x_5)+\delta(x_5-\pi\cdot R)\right]\right\} \tag{52}$$

Here, what is called m_5^2 can be linked to Kaluza Klein "excitations" via (for a number $n > 0$)

$$m_n^2 \equiv \frac{n^2}{R^2} + m_5^2 \tag{53}$$

To use Kaluza-Klein theory, as in [27], we use an invariant metric on S^1 that is the fiber of the $U(1)$-bundle of electromagnetism. This leads to construction of, by [27] and [28]

$$S_5 = -\int \mathrm{d}^4x\cdot V_{eff}\left(R_{phys}(x)\right) \to -\int \mathrm{d}^4x\cdot \tilde{V}_{eff}\left(R_{phys}(x)\right) \tag{54}$$

$$\tilde{V}_{eff}\left(R_{phys}(x)\right) = \frac{K^2}{2\cdot m_5}\cdot\frac{1+\exp\left(m_5\cdot\pi\cdot R_{phys}(x)\right)}{1-\exp\left(m_5\cdot\pi\cdot R_{phys}(x)\right)} + \frac{\tilde{K}^2}{2\cdot\tilde{m}_5}\cdot\frac{1-\exp\left(\tilde{m}_5\cdot\pi\cdot R_{phys}(x)\right)}{1+\exp\left(\tilde{m}_5\cdot\pi\cdot R_{phys}(x)\right)} \tag{55}$$

Start with

$$\Psi \propto \exp\left(-\int \mathrm{d}^3x_{\text{space}}\mathrm{d}\tau_{\text{Euclidian}}L_E\right) \equiv \exp\left(-\int \mathrm{d}^4x\cdot L_E\right) \tag{56}$$

The above in our integral, as in this treatment makes use of the following quadratic approximation. *I.e.* if Q is a charge, then

$$L_E \geq |Q| + \frac{1}{2}\cdot\left(\tilde{\phi}-\phi_0\right)^2\{\ \} \xrightarrow[Q\longrightarrow 0]{} \frac{1}{2}\cdot\left(\tilde{\phi}-\phi_0\right)^2\cdot\{\ \} \tag{57}$$

Part of the integrand in Equation (54) is known as an action integral, $S = \int L\mathrm{d}t$. We use Euclidian time, via $\tau = i\cdot t$ to invert our potential, and to then allow the quantum bounce hypothesis of Sidney Colman. Then, here, the spatial dimension $R_{phys}(x)$ is defined so that

$$\tilde{V}_{eff}\left(R_{phys}\left(x\right)\right) \approx \text{constant} + 1/2 \cdot \left(R_{phys}\left(x\right) - R_{\text{critical}}\right)^2 \propto \tilde{V}_2\left(\tilde{\phi}\right) \propto \frac{1}{2} \cdot \left(\tilde{\phi} - \phi_C\right)^2 \quad (58)$$

And

$$\{\ \} = 2 \cdot \Delta \cdot E_{gap} \quad (59)$$

We should note that the quantity $\{\ \} = 2 \cdot \Delta \cdot E_{gap}$ referred to above has a shift in minimum energy values between a false vacuum minimum energy value, $E_{\text{false min}}$, and a true vacuum minimum energy $E_{\text{true min}}$, with the difference in energy reflected in Equation (59). Note what was done by the Japanese theorists. We obtain the following simplification, namely

$$\tilde{V}_{eff}\left(R_{phys}\left(x\right)\right) \approx \text{Constant} + 1/2 \cdot \left(R_{phys}(x) - R_{\text{critical}}\right)^2 \propto V_0 + \frac{m}{2} \cdot \left[\phi - \varphi_{\text{fluctuations}}\right]^2_{4\text{-dim}} \quad (60)$$

For convenience we have made the substitution as given in Equation (61).

$$\text{Constant} \leftrightarrow V_0 \quad (61)$$

The upshot is that the following simplification appears to hold as in Equation (62).

$$1/2 \cdot \left(R_{phys}\left(x\right) - R_{\text{critical}}\right)^2 \leftrightarrow \frac{m}{2} \cdot \left[\phi - \varphi_{\text{fluctuations}}\right]^2_{4\text{-dim}} \quad (62)$$

All these final steps need to be confirmed in the future by rigorous analysis.

9. Using Our Bound to the Cosmological Constant

We use our bound to the cosmological constant to obtain a conditional escape of gravitons from an early universe brane. To begin, we present conditions (Leach and Lesame, 2005) [29] for gravitation production. Here R is proportional to the scale factor "distance".

$$B^2\left(R\right) = \frac{f_k\left(R\right)}{R^2} \quad (63)$$

Also there exists an "impact parameter"

$$b^2 = \frac{E^2}{P^2} \quad (64)$$

This leads to, practically, a condition of "accessibility" via R so defined with respect to "bulk dimensions"

$$b \geq B\left(R\right) \quad (65)$$

$$f_k\left(R\right) = k + \frac{R^2}{l^2} - \frac{\mu}{R^2} \quad (66)$$

Here, $k = 0$ for flat space, $k = -1$ for hyperbolic three space, and $k = 1$ for a three sphere, while an radius of curvature

$$l \equiv \sqrt{\frac{-6}{\Lambda_{5\text{-dim}}}} \quad (67)$$

This assumes a negative bulk cosmological constant $\Lambda_{5-\text{dim}}$ and that μ is a five-dimensional Schwartz shield mass. We assume emission of a graviton from a bulk horizon via scale factor, so $R_b\left(t\right) = a\left(t\right)$. Then we have a maximum effective potential of gravitons defined via

$$B^2\left(R_t\right) = \frac{1}{l^2} + \frac{1}{4 \cdot \mu} \quad (68)$$

This leads to an upper bound with respect to release of a graviton from an anti De Sitter brane (Leach and Lesame, 2005) [29] we write as

$$b \geq B\left(R_t\right) \quad (69)$$

In the language of general relativity, anti de Sitter space is the maximally symmetric, vacuum solution of Einstein's field equation with a negative cosmological constant Λ.

How do we link this to our problem with respect to di quark contributions to a cosmological constant? Here we make several claims. These are all from [28] [29]

Claim 1: We reset $l \equiv \sqrt{-6/\Lambda_{5\text{-dim}}}$ as

$$l_{eff} = \sqrt{\left|\frac{6}{\Lambda_{eff}}\right|} \tag{70}$$

Proof of Claim 1: We are noting that the end result is that

$$\Lambda_{5\text{-dim}} \xrightarrow[\text{external temperature}\to\text{small}]{} \text{Large value} \tag{71}$$

And we take the value of the five dimensional value to be in magnitude presentable as

$$\left|\Lambda_{5\text{-dim}}\right| = \Lambda_{eff} \tag{72}$$

Note how $\cdot\Lambda_{4\text{-dim}}$ is defined by Park [4] with $\varepsilon^* = \frac{U_T^4}{k^*}$ and $U_T \propto (\text{external temperature})$, and $k^* = \left(\frac{1}{\text{'AdS curvature}}\right)$ so that we then can take the following given limiting process, as approaching today's value of the Cosmological Constant. Then

$$\cdot\Lambda_{4\text{-dim}} = 8 \cdot M_5^3 \cdot k^* \cdot \varepsilon^* \xrightarrow[\text{external temperature}\to 3\text{ Kelvin}]{} (0.0004\text{ eV})^4 \tag{73}$$

Here, we define Λ_{eff} as being an input from Equation (20) to Equation (21) to Equation (22) due to,

$$\begin{aligned} &\Delta\Lambda_{\text{total}}\Big|_{\text{effective}} = \lambda_{\text{other}} + \Delta V \\ &\xrightarrow[\Delta V \to \text{end chaotic inflation potential}]{} \Lambda_{\text{observed}} \cong \Lambda_{4\text{-dim}}(3\text{ Kelvin}) \end{aligned} \tag{74}$$

The upshot is that we have an approaching to the 3 Kelvin background temperature, as in present day Space-time.

This, for potential $V_{\min}$, is defined via transition between the first and the second potentials of Equation (21) and Equation (22)

$$B_{eff}^2(R_t) = \frac{1}{l_{eff}^2} + \frac{1}{4\cdot\mu} \tag{75}$$

Claim 2: $R_b(t) = a(t)$ ceases to be definable for times where the upper bound to the time limit is in terms of Planck time and in fact the entire idea of a de Sitter metric is not definable in such a physical regime. This is a given in standard inflationary cosmology where traditionally the scale factor in cosmology is a, parameter of the Friedmann-Lemaître-Robertson-Walker model, and is a function of time which represents the relative expansion of the universe. It relates physical coordinates (also called proper coordinates) to co moving coordinates. For the FLRW model

$$L = \bar{\bar{\lambda}} \cdot a(t) \tag{76}$$

where L is the physical distance $\bar{\bar{\lambda}}$ is the distance in co moving units, and $a(t)$ is the scale factor. While general relativity allows one to formulate the laws of physics using arbitrary coordinates, some coordinate choices are natural choices, which are easy to work with. *Comoving coordinates* are an example of such a natural coordinate choice. They assign constant spatial coordinate values to observers who perceive the universe as isotropic. Such observers are called *comoving observers* because they move along with the Hubble flow. *Comoving distance* is the distance between two points measured along a path of constant cosmological time. It can be computed by using t_e as the lower limit of integration as a time of emission

$$\bar{\bar{\lambda}} \equiv \int_{t_e}^{t} \frac{c \cdot \mathrm{d}t'}{a(t')} \tag{77}$$

This claim 2 breaks down completely when one has a strongly curved space, which is what we would expect in the first instant of less than Planck time evolution of the nucleation of a new universe.

Claim 3: Equation (74) has a first potential which tends to be for a di quark nucleation procedure which just before a defined Planck's time t_P. But that the cosmological constant was prior to time t_P likely far higher, perhaps in between the values of the observed cosmological constant of today, and the QCD tabulated cosmological constant which is 10^{120} time greater. *i.e.*

$$b^2 \geq B_{eff}^2\left(R_t\right) = \frac{1}{l_{eff}^2} + \frac{1}{4\cdot\mu} \tag{78}$$

Which furthermore

$$\left.\frac{1}{l_{eff}^2}\right|_{t\leq t_P} \gg \left.\frac{1}{l_{eff}^2}\right|_{t\equiv t_P+\Delta(\text{time})} \tag{79}$$

So then that there would be a great release of gravitons at or about time t_P.

Claim 4: Few gravitons would be produced significantly after time t_P.

Proof of Claim 4: This comes as a result of temperature changes after the initiation of inflation and changes in value of [29]

$$\left(\Delta l_{eff}\right)^{-1} = \left(\sqrt{\left|\frac{6}{\Lambda_{eff}}\right|}\right)^{-1} \propto \Delta\left(\text{external temperature}\right) \tag{80}$$

After this, we need to discuss how this thermal input into the axion wall occurs, leading to these results.

10. Di Quark Potential Systems and the Wheeler De-Witt Equation

Abbay Ashtekar's quantum bounce results as given in [11] and [12] are redone by Henriques and gives a discrete version of the Wheeler De Witt equation [30]. We begin with the results given in [30]

$$\psi_\mu(\phi) \equiv \psi_\mu \cdot \exp\left(\alpha_\mu \cdot \phi^2\right) \tag{81}$$

As well as energy term

$$E_\mu = \sqrt{A_\mu \cdot B_\mu} \cdot m \cdot \hbar \tag{82}$$

$$\alpha_\mu = \sqrt{B_\mu / A_\mu} \cdot m \cdot \hbar \tag{83}$$

This is for a "cosmic" Schrodinger equation as given by [30]

$$\tilde{\tilde{H}} \cdot \psi_\mu(\phi) = E_\mu(\phi) \tag{84}$$

This has V_μ is the eigenvalue of a so called volume operator. So:

$$A_\mu = \frac{4\cdot m_{pl}}{9\cdot l_{pl}^9} \cdot \left(V_{\mu+\mu_0}^{1/2} - V_{\mu-\mu_0}^{1/2}\right)^6 \tag{85}$$

And

$$B_\mu = \frac{m_{pl}}{l_{pl}^3} \cdot \left(V_\mu\right) \tag{86}$$

Ashtekar [11] [12] works with as a simplistic structure with a revision of the differential equation assumed in Wheeler-De Witt theory to a form characterized by $\partial^2/\partial\phi^2 \cdot \Psi \equiv -\Theta \cdot \Psi$, and $\Theta \neq \Theta(\phi)$. This will lead to Ψ having roughly the form alluded to in Equation (81), which in early universe geometry will eventually no longer be L^P, but will have a discrete geometry. This may permit an early universe "quantum bounce" and an outline of an earlier universe collapsing, and then being recycled to match present day inflationary expansion parameters. The main idea behind the quantum theory of a (big) quantum bounce is that, as density approaches infinity, so the behavior of the quantum foam changes. The foam is a qualitative description of the turbulence that the phenomenon creates at extremely small distances of the order of the Planck length. Here V_{μ} is the eigenvalue of a so called volume operator and we need to keep in mid that the main point made above, is that a potential operator based upon a quadratic term leads to a Gaussian wave function with an exponential similarly dependent upon a quadratic ϕ^2 exponent. To get to this, we need to consider a discrete wave functional for a modified Wheeler de Witt equation we would write up as follows. The point is that if we understand the contribution of Equation (81) above to space time dynamics, we will be able to confirm or falsify the existence of space time conditions as given by a non L^P structure as implied below. This will entail either confirming or falsifying the structure given to Θ. Also, and more importantly the above mentioned Θ is a difference operator, allowing for a treatment of the scalar field as an "emergent time", or "internal time" so that one can set up a wave functional built about a Gaussian wave functional defined via

$$\max \tilde{\Psi}(k) = \tilde{\Psi}(k)\Big|_{k \equiv k^*} \tag{87}$$

This is for a crucial "momentum" value [11] [12] [30]

$$p_{\phi}^* = -\left(\sqrt{16 \cdot \pi \cdot G \cdot \hbar^2 / 3}\right) \cdot k^* \tag{88}$$

And

$$\phi^* = -\sqrt{3/16 \cdot \pi G} \cdot \ln\left|\mu^*\right| + \phi_0 \tag{89}$$

Which leads to, for an initial point in "trajectory space" given by the following relation $\left(\mu^*, \phi_0\right) =$ (initial degrees of freedom [dimensionless number] ~ eigenvalue of "momentum", initial "emergent time") So that if we consider Eigen functions of the De Witt (difference) operator, as contributing toward

$$e_k^s(\mu) = \left(1/\sqrt{2}\right) \cdot \left[e_k(\mu) + e_k(-\mu)\right] \tag{90}$$

With each $e_k(\mu)$ an Eigen function of Θ above, we have a potentially numerically treatable early universe wave functional data set which can be written as

$$\Psi(\mu, \phi) = \int_{-\infty}^{\infty} \mathrm{d}k \cdot \tilde{\Psi}(k) \cdot e_k^s(\mu) \cdot \exp\left[i\omega(k) \cdot \phi\right] \tag{91}$$

The existence of gravitons in itself would be able to either confirm or falsify the existence of non L^P structure in the early universe. This structure was seen as crucial to Ashtekar, A, Pawlowski, T. and Singh, in their arXIV article [11] [12] make reference to a revision of this momentum operation along the lines of basis vectors $\left|\mu\right\rangle$ by

$$\hat{p}_{\iota}\left|\mu\right\rangle = \frac{8 \cdot \pi \cdot \gamma \cdot l_{PL}^2}{6} \cdot \mu\left|\mu\right\rangle \tag{92}$$

With the advent of this re definition of momentum we are seeing what Ashtekar [11] [12] works with as a simplistic structure with a revision of the differential equation assumed in Wheeler—De Witt theory to a form characterized by [11] [12]

$$\frac{\partial^2}{\partial \phi^2} \cdot \Psi \equiv -\Theta \cdot \Psi \tag{93}$$

Θ in this situation is such that

$$\Theta \neq \Theta(\phi) \tag{94}$$

This in itself would permit confirmation of if or not a quantum bounce condition existed in early universe geometry, according to what Ashtekar's two articles predict [11] [12]. In addition it also corrects for another problem. Prior to brane theory we had a too crude model. Why? When we assume that a radius of an early universe—assuming setting the speed of light $c \equiv 1$ is of the order of magnitude 3 $\cdot\left(\Delta t \cong t_P\right)$—we face a rapidly changing volume that is heavily dependent upon a first order phase transition, as affected by a change in the degrees of freedom given by $\cdot\left(\Delta N\left(T\right)\right)_P$. Without gravitons and brane world structure, such a model is insufficient to account for dark matter production and fails to even account for Baryogenesis. It also will lead to new graviton detection equipment re configuration well beyond the scope of falsifiable models configured along the lines of simple phase transitions given for spatial volumes (assuming $c = 1$) of the form [13]

$$\Delta t \cong t_P \propto \frac{1}{4\pi}\cdot\sqrt{\frac{45}{\pi\cdot\left(\Delta N\left(T\right)\right)_P}}\cdot\left(\frac{M_p}{T^2}\right) \tag{95}$$

This creates problems, so we look for other ways to get what we want. Grushchuk writes that the energy density of relic gravitons is expressible as [32]

$$\varepsilon\left(v\right) \equiv \frac{\pi}{\left(2\cdot\pi\right)^4}\cdot\frac{1}{a\left(t\right)^4}\cdot H_i^2\cdot H_f^2\cdot a\left(t\right)_f^4 \tag{96}$$

where the subscripts i and f refer to initial and final states of the scale factor, and Hubble parameter. This expression though is meaningless in situations when we do not have enough data to define either the scale factor, or Hubble parameter at the onset of inflation. How can we tie in with the Gaussian wave functional $\tilde{\Psi}\left(k\right)$ defined as an input into the data used to specify Ashtekar's quantum bounce? Here, we look at appropriate choices for an optimum momentum value for specifying a high level of graviton production. If gravitons are, indeed, for dark energy, as opposed to dark matter, without mass, we can use, to first approximation something similar to using the zeroth component of momentum $p^0 = E\left(\text{energy}\right)/c$, calling $E\left(\text{energy}\right) \equiv \varepsilon\left(v\right)\cdot$ (initial nucleation volume), we can read off from Equation (73) "pre inflationary" universe values for the k values of Equation (87) can be obtained, with an optimal value selected. This is equivalent to using to first approximation the following. The absolute value of k^*, which we call $\left|k^*\right|$ is

$$\left|k^*\right| = \sqrt{3/16\cdot\pi\cdot G\cdot\hbar^2}\cdot\left(\varepsilon\left(v\right)\cdot\left(\text{initial nucleation volume}\right)/c\right) \tag{97}$$

An appropriate value for a Gaussian representation of an instanton awaits more detailed study. But for whatever it is worth we can refer to the known spaleraton value for a multi dimensional instanton via the following procedure. We wish to have a finite time for the emergence of this instanton from a pre inflation state.

If we have this, we are well on our way toward fixing a range of values for $\omega 2 < \omega\left(net\right) < \omega 1$, which in turn will help us define

$$\varepsilon\left(v\right)\cdot\left(\text{initial volume}\right) \approx \hbar\cdot\omega\left(\text{net}\right) \equiv p^*\cdot c \tag{98}$$

in order to get a value for k^*. This value for k^* can then is used to construct a Gaussian wave functional about k^* of the form, as an anzatz.

$$\Psi\left(k\right) \approx \frac{1}{\text{Value}}\cdot\exp\left(-c_2\cdot\left(k-k^*\right)^2\right) \tag{99}$$

If so, then, most likely, the question we need to ask though is the temperature of the "pre inflationary" universe and its link to graviton production. This will be because the relic graviton production would be occurring before the nucleation of a scalar field. We claim, as beforehand that this temperature would be initially quite low, but then rising to a value at or near 10^{12} degrees Kelvin after the dissolving of the axion wall contribution given in the dominant value of Equation (21) leading to Equation (22) for a chaotic inflationary potential. And now we shall consider why we need to look at relic graviton production, anyway.

11. Detecting Gravitons as Spin 2 Objects with Available Technology

To briefly review what we can say now about standard graviton detection schemes, as mentioned above, Rothman wrote that Dyson doubts we will be able to detect gravitons via present detector technology [33]

$$\frac{f_\gamma\cdot\sigma}{4\cdot\pi}\cdot\left(\frac{\alpha}{\alpha_g}\right)^{3/2}\cdot\frac{M_s}{R^2}\cdot\frac{1}{\varepsilon_\gamma} \geq 1 \tag{100}$$

Here, at best, we usually can set $f_\gamma = 0.02$, which does not help us very much, and which is seen to be what we get with

$$f_\gamma = \frac{L_\gamma}{L} \tag{101}$$

This in part is why we are looking at relic graviton production for early universe models, usually detectable via the criteria developed for white dwarf stars of one graviton for 10^{13-14} neutrinos [34].

Furthermore, $\alpha = e^2/\hbar$ and $\alpha_g = Gm_p^2/\hbar$ a constant while ε_γ is the graviton potential energy.

We should state that we will generally be referring to a cross section which is frequently the size of the square of Planck's length l_p which means we really have problems in detection, if the luminosity is so low.

Note that we obtainnn upper bound to the cross section σ for a graviton production process $\approx 1/M$ with *M*-Planck scale in 4 + *n* dimensions $\equiv \left(M_P^2/\hat{V}_n\right)^{1/2+n}$, and this is using a very small $\hat{V}$ -Compactified early universe extra dimension "square" volume ≈ 10 - 15 mm per side. So, having this limitation, Chongqing University is looking at objects like Neutron stars, as Graviton detection sites, and the like. It is a serious problem, and one which mandates serious choices of GR/ Graviton detection, to be thoroughly vetted by appropriate astrophysical models.

12. Conclusions

Note that if the Rothman analysis [33] is accurate, we need to look at sampling data from Neutron stars and the like as graviton emitter candidates to further increase the likelihood of graviton detection. . We should also note using material from [34]-[42]. Secondly, we state that the idea of using a graviton detector the size of Jupiter as an instrument is absurd. We need to pioneer new Graviton detector technology, rather than what Rothman envisions. Third, we also need to ask how one could go say from 10^{12} Kelvin as pre Big Bang temperature up to Plank temperatures for observing a graviton burst, *i.e.* the supposition of Caroll and Chen [5] is very attractive as a model, but the question of how to model such a huge temperature increase is open and needs proper analysis.

We can point to the following as tentative successes of our model which need further elaboration.

Gravitons would appear to be produced in great number in the $\Delta t \approx t_P$ neighborhood, according to a brane world interpretation just given. This depends upon the temperature dependence of the "cosmological constant". For a critical temperature T_C is defined in the neighborhood of an initial grid of time $\Delta t \approx t_P$. We need to reverse engineer conditions which would give a chance of using indirect ways to observe this sort of graviton production, via methods similar to what S. L. Shapiro and S. Teukolosky [34] wrote up in "Black holes, white dwarfs, and Neutron stars", John Wiley and Sons, New York, New York, 1983 that they fixed a ratio between gravitons and neutrinos.

A Randall-Sundrum effective potential, as outlined herein, would give a structure for embedding an earlier axion potential, which would be a primary candidate for an initial configuration of dark energy. This structure would, by baryogenesis, be a shift to dark energy. We need to determine if the sets of JDEM space observations have data which could be configured to determine if WIMPS are in any way tied into the supposed dark energy released after a $\Delta t \approx t_P$ time interval.

In doing this, we should note the following. We have reference multiple reasons for an initial burst of graviton activity, *i.e.* if we wish to answer Freeman Dyson's question about the existence of gravitons in a relic graviton stand point [35].

We have already found it necessary to avoid the methodology of [36], for working on the Cosmological constant problem. We wish to obtain, via Parks [4] method of linking, four and five dimensional cosmological constants in a way to obtain a temperature based initial set of conditions for this parameter, which would eliminate the need for the scale factor being appealed to all together.

A lot of work can and should be done to update the power law for graviton production along the lines of an update to the graviton power spectra expression via taking into account a per solid angle expression.

As I was asked about earlier, this does have a directional component which was given by Weinberg in 1972 [1] as the power per solid angle

$$\frac{\mathrm{d}P}{\mathrm{d}\Omega} = \frac{G \cdot \omega_{net}^6}{4 \cdot \pi} \cdot \Lambda_{ij,lm}(k) \cdot D_{ij}^*(\omega) \cdot D_{lm}(\omega) \tag{102}$$

where we can write $D_{ij}(\omega)$ in terms of a Fourier transform of the $T_{ij}(x,\omega)$ energy- momentum tensor

$$D_{ij}(\omega) \equiv -\frac{2}{\omega^2} \cdot T_{ij}(k,\omega) \tag{103}$$

Getting realistic values of $T_{ij}(x,\omega)$ will entail a lot of work and will entail trying to make sense of curvature conditions at the onset of inflation which are currently glossed over. If we can make sense of this, we will be fulfilling the aims of practical applications of graviton physics.

Also, the issues raised in [37] need to be settled. Do we have color super conductor type conditions in the early universe as stated by Zhitinisky?

Doing all of this will enable us, once we understand early universe conditions, to be able to initiate de facto engineering work pertinent to power source engineering. We will initiate engineering work so as to allow this concept to become the basis of new space craft technology. Also in order to do this engineering work properly we need to understand the issues raised in [38]-[40]. We will state that details of the four and five dimensional Cosmological constant touches upon Corda's question as to the ultimate nature of gravity as in [38]. Furthermore, our discussion and analysis should confirm if [39] holds, and if the known experimental constraints of [40] [41] hold. In addition, our analysis has heavily used Ng's infinite quantum statistics [42] which should be falsified by experiments.

As to reference [43] we refer to confirmation or rejection of the ideas of a causal discontinuity, at the start of cosmological evolution and space-time physics as necessary. Finally, and not least, it is also experimental vetting of the ideas as given in [44] as to the existence, or falsification of an initially non singular universe, as given by Gao *et al*. We use the Gao's structure as given in [44], or we use the non singular start to the universe as given by Non Linear Electrodynamics, as in reference [45].

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